

# OFFICIAL PUBLICATIONS OF CORNELL UNIVERSITY

VOLUME II

NUMBER 11

## ANNOUNCEMENT OF THE COLLEGE OF CIVIL ENGINEERING 1911-12

JUNE 1, 1911  
PUBLISHED BY CORNELL UNIVERSITY  
ITHACA, NEW YORK





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## CORNELL UNIVERSITY CALENDAR

1911-1912

Sept. 15,	Friday,	Entrance Examinations begin.
Sept. 25-26,	Monday-Tuesday,	Registration, New Students.
Sept. 27,	Wednesday,	Registration, Old Students.
Sept. 28,	Thursday,	Instruction begins.
Sept. 30,	Saturday,	Registration, Graduate School.
Oct. 17,	Tuesday,	Tuition, Last day for payment.
Nov. —,	Thursday-Friday,	Thanksgiving Recess.
Dec. 20,	Wednesday,	Instruction ends.
Jan. 3,	Wednesday,	Instruction resumed.
Jan. 11,	Thursday,	Founder's Day.
Jan. 27,	Saturday,	Instruction ends.
Jan. 29,	Monday,	Term examinations begin.
Feb. 10,	Saturday,	Registration, Undergraduates.
Feb. 12,	Monday,	Registration, Graduate School.
Feb. 12,	Monday,	Instruction begins.
Mar. 1,	Friday,	Tuition, Last day for payment.
April 3,	Wednesday,	Instruction ends.
April 9,	Tuesday,	Instruction resumed.
June 1,	Saturday,	Navy Day.
June 3,	Monday,	Term examinations begin.
June 20,	Thursday,	Commencement.



# COLLEGE OF CIVIL ENGINEERING

## FACULTY

- Jacob Gould Schurman, A.M., D.Sc., LL.D., President.
- Eugene Elwin Haskell, C.E., Director of the College of Civil Engineering and Professor of Experimental Hydraulics.
- Charles Lee Crandall, C.E., M.C.E., Professor of Railroad Engineering.
- Irving Porter Church, C.E., M.C.E., Professor of Applied Mechanics and Hydraulics, in charge of the College Library.
- Henry Sylvester Jacoby, C.E., Professor of Bridge Engineering.
- Henry Neely Ogden, C.E., Professor of Sanitary Engineering.
- John Thomas Parson, Assistant Professor of Drawing, in charge of the Photographic and Drawing Collections.
- Ernest William Schoder, B.S., Ph.D., Assistant Professor of Experimental Hydraulics, in charge of the Hydraulic Laboratory.
- Fred Asa Barnes, C.E., M.C.E., Assistant Professor of Railroad Engineering.
- Ora Miner Leland, B.S., C.E., Assistant Professor of Geodesy and Astronomy.
- Miles Albion Pond, Ph.B., Assistant Professor of Civil Engineering, in charge of Descriptive Geometry.
- Francis Joseph Seery, S.B., Assistant Professor of Civil Engineering.
- Donald Derickson, C.E., Assistant Professor of Structural Engineering.
- Samuel Latimer Boothroyd, B.S., M.S., Assistant Professor of Topographic and Geodetic Engineering.
- Ernest William Rettger, A.B., Ph.D., Assistant Professor of Applied Mechanics.
- Sidney Gonzales George, C.E., Assistant Professor of Applied Mechanics and Secretary of the College Faculty.
- Charles Leopold Walker, C.E., Assistant Professor of Applied Mechanics.
- Kenneth Bertrand Turner, C.E., M.C.E., Assistant Professor of Hydraulics.
- Adelbert Philo Mills, B.S., (C.E.), M.S., (C.E.), Assistant Professor of Testing Materials.
- Latta Vanderion Edwards, B.E., Instructor in Civil Engineering.
- Paul Halladay Underwood, C.E., Instructor in Topographic and Geodetic Engineering.
- Roland Parker Davis, S.B., M.C.E., Instructor in Bridge Engineering.
- Leonard Alexander Lawrence, B.S., Instructor in Surveying.
- John Clarence McCurdy, B.S., Instructor in Surveying.
- Ralph McLane Bowman, C.E., Instructor in Bridge Engineering.
- Edward Hooker Taylor, B.S. in C.E., Instructor in Civil Engineering.
- William Harley Morris, C.E., Instructor in Civil Engineering.
- Edward Vahan Baron, B.S., C.E., Instructor in Civil Engineering.
- Earle Nelson Burrows, C.E., Instructor in Civil Engineering.
- Nathan Washington Dougherty, B.S. in C.E., Instructor in Civil Engineering.
- 
- Gertrude Marsh Sanford, College Librarian.
- Eleanor E. Illston, Secretary to the Director.
- Lena K. Haylett, College Stenographer.
- Clinton D. Cass, College Mechanician.

### GENERAL PLAN OF STUDIES

The courses of preparatory and professional studies have been planned with a view to laying a substantial foundation for the general and technical knowledge needed by practitioners in civil engineering so that our graduates, guided by their theoretical education and as much of engineering practice as can well be taught in schools, may develop into useful investigators and constructors.

The facilities for instruction and for advanced investigations are believed to be thorough and efficient. Laboratory work is required in chemistry, mineralogy, geology, mechanics, testing materials, and hydraulics. In addition to the special library and laboratories of the College, all the other libraries, collections and laboratories of the University are open to the students of this College.

The work of the student comprises an extended course in mathematics, mechanics, and graphics, and in their applications to engineering. The object aimed at is to give as thorough a preparation as possible for the general purposes of the profession in the following subjects: the survey, location and construction of roads, railroads, canals, and water works; the construction of foundations under water and on land, and of superstructures and tunnels; the survey, improvement, and protection of coasts, and the regulation of rivers, harbors and lakes; the astronomical determination of geographical coordinates for geodetic and other purposes; the application of mechanics, graphical statics, and descriptive geometry to the construction of the various kinds of arches, girders, roofs, trusses, suspension and cantilever bridges; the drainage of districts, sewerage of towns, and the irrigation and reclaiming of land; the design, construction, application and tests of hydraulic and electric motors, and steam engines; the preparation of drawings, plans and specifications, and the proper inspection and tests of the materials used in construction. Instruction is given in engineering economy, finance and jurisprudence. The latter subject deals in an elementary manner with the questions of easements and servitudes, and the ordinary principles of the laws of contracts and riparian rights.

The College of Civil Engineering is quartered in Lincoln Hall, a substantial brown stone structure, two hundred feet long and seventy feet wide, specially designed for its purpose. In addition to the laboratories and museums, the building contains the working library of the College, aggregating about four thousand volumes, reading-rooms, class-rooms, and draughting-rooms. The astronomical and portions of the geodetic equipment are housed in the Fuertes Observatory containing all the instruments required for finding time, latitude, longitude and azimuth. The instruments are duplicates, in the main, of similar ones in use by the Coast and Geodetic Survey. The large hydraulic laboratory with its buildings and equipment is located at the Fall Creek gorge, within a short distance of the College building.



## LABORATORIES

**The Civil Engineering Laboratories** are located in three distinct buildings and comprise the following:

1. **A Laboratory of Mechanics** in the basement of Lincoln Hall, containing a collection of machines and appliances for the experimental illustration and application of the principles and subjects taught in the class room, and as preparation for special laboratories. It contains:

Numerous computing instruments, such as ordinary slide rules, Fuller spiral slide rules, Thacher calculating instruments, and Goodchild charts. Amsler mechanical integrators and planimeters, both for areas and moments of inertia. A cathetometer, in connection with a weighing scale, for observing elongations of steel and other wires. A smaller cathetometer for miscellaneous purposes. Various mechanical appliances: such as funicular polygons; wooden trusses for measurement of stresses in members; a "Willis apparatus" crane for efficiency tests; systems of levers; Jolly balances for determination of specific gravity; polygonal plates of sheet metal and wooden prismoids, for finding centers of gravity.

An inclined plane of glass and metal for efficiency tests, springs and weights for harmonic motion of suspended bodies. A Kater pendulum.

A 50,000 lb. and a 100,000 lb. Olsen testing machine for testing metals in tension and compression, a Henning extensometer and a dial extensometer for use with same. A Thurston autographic torsion testing machine for small test pieces. A Riehle torsion testing machine, of 60,000 inch-lbs. capacity, for testing rods and shafts up to one and a half inches in diameter and length of six feet. Torsion clinometers, for use with the Riehle machine and reading to single minutes of arc, for determining angles of torsion. A compression machine of capacity of 4,000 lbs., for testing wooden columns up to eight feet in length. Two machines for flexural tests of bars of metal and wood, with observation of deflections.

The Kew magnetometer and dip-circle, for observations on the magnetism of the earth.

2. **A Cement Laboratory.** This laboratory contains machines for tension tests, compression machines of from two to two hundred tons capacity, an impact machine, and a special machine for determining automatically the rate of setting and hardening of cement. For direct experiment with cement there is also provided a large number of tension and compression briquette moulds, a water tank with capacity for the storage of three thousand briquettes, a moist oven with a capacity of seven hundred briquettes, and three drying ovens; scales, slate and plate-glass mixing tables, thermometers, a Bunsen pump for determining permeability, several sets of apparatus for measuring linear and volume changes during setting, and apparatus for determining specific gravity, normal consistency, and time of set, and constancy of volume by normal and accelerated tests; also standard sieves for determining fineness, and apparatus for determining voids in sand and stone.

**The Equipment of the Testing Laboratory** for materials of construction and for full sized members, joints, and structures includes: a Riehle 400,000 lb. testing machine with a capacity for beams and girders up to 19 inches in width and to 18 feet in length and for specimens in tension and compression

up to 12 ft. in length; a Riehle 100,000 lb. testing machine, and an Olsen 50,000 lb. machine; an Olsen 10,000 lb. wire testing machine; a Thurston autographic torsion testing machine; a Riehle torsion testing machine of 60,000 inch-pounds capacity, for testing rods and shafts up to one and a half inches in diameter and six feet in length; a Riehle 5,000 lb. transverse load testing machine for flexural tests of bars of wood and metal up to four feet in length; an Amsler-Laffron compression testing machine; a standard Page impact machine for tests of road material; a Riehle grinder for stone specimens; a standard Deval machine for abrasion tests of road material; and a standard rattler for paving brick.

The equipment also includes a set of torsion clinometers for use with the Riehle torsion machine; a Henning extensometer for tension tests of metals, and two self indicating dial extensometers with fittings which adapt them for use in testing steel or iron tension or compression specimens, and also for testing full sized concrete beams and columns and for tests of wire. The Martens mirror extensometer is also available. Knock-down forms are provided for the making of large concrete beams and columns.

### EXPERIMENTAL HYDRAULICS

**The Hydraulic Laboratory** by reason of its unique location and unusual facilities is adapted to investigations of great value to hydraulic science and the engineering profession. The water supply is obtained from Fall Creek with a watershed of 126 square miles. Beebe Lake, a pond of about 20 acres, has been formed by the construction of a concrete dam 26 feet high, with a spillway crest length of 130.5 feet. At one end of the dam there is an additional flood spillway 141.5 feet long. A rectangular canal 420 feet long and 16 feet wide is supplied from Beebe Lake through six headgates for controlling the amount of flow. The upper portion of the canal is 17.7 feet deep and the lower portion is 10 feet deep. In this canal are two sharp crested weirs 16 feet long over which discharges as large as 400 cubic feet per second may be passed.

A branch canal 6 feet wide leads from the lower end of the large 16-foot canal into the upper portion of the laboratory building which is built against the cliff of the gorge. This branch canal may also be supplied directly from Beebe Lake by means of a 48-inch cast iron pipe line with a short 30-inch branch at its lower end. Two sluice gates control the flow from the large canal, and a 30-inch valve controls the flow from the 48-inch pipe into the 6-foot canal. The 6-foot canal within the laboratory building discharges either to waste into the pool below Triphammer Falls (a sheer drop of 60 feet) or into the upper end of a steel standpipe 6 feet in diameter and 60 feet high. A suitable mechanism causes an instantaneous diversion of discharges as large as 60 cubic feet per second from the waste flume into the standpipe or vice versa. The 6-foot standpipe is provided at the bottom with a 36-inch discharge valve operated by hydraulic pressure. There is a float gage indicating accurately the height of the water surface in the standpipe.

The lower portion of the large 16-foot canal, 350 feet long between weirs, is used for measurements with floats and current meters. An electrically operated car spans this canal and is used for rating the current meters.



Models of dams may be built in the canal and the flow over them investigated with precision.

There is an outdoor equipment for pipe flow experiments with pipes as large as 6 inches in diameter with a concrete tank for precise measurements of flow. The 8-inch pipe line supplying the University filtration plant is available for experimentation, giving a head of 225 feet.

A concrete Cippoletti weir with steel edges and with a crest length of 16 feet, and depth of notch of 6.5 feet is built in the gorge below Beebe Lake dam and serves to measure the creek flow to calibrate the dam and the 5-foot flood gate in the dam.

Part of the equipment of the University power plant may also be used for certain kinds of hydraulic experimentations. The available head here is 135 feet.

Although the laboratory needs still further additions to its very expensive equipment, the utility of this plant has been demonstrated by calls from all parts of the country for the performance of experiments of great importance. Among these may be mentioned the valuable results obtained for the U. S. Deep Waterways Commission, the Michigan Lake Superior Power Company, the City of New York in connection with its water supply, and for the U. S. Geological Survey.

5. **A Metric Laboratory** for the comparison of standards of lengths. The room is built with hollow double walls, and the daily range of temperature can be kept within 1° F. The four-meter comparator is of the Repsold type, but with the beam supporting the two micrometer microscopes resting on piers independent from those supporting the bed or main framework. The cradle supporting the two bars under comparison can be moved so as to bring first one and then the other under the microscopes by a crank outside of the case which protects the apparatus from sudden temperature changes due to the presence of the observer. The standard of length is a steel meter bar of the International type which has been compared with the International Standard at the Coast and Geodetic Survey Office. There is also a Rogers speculum metal decimeter and 4-inch scale combined, accurately divided and compared, and a 4-meter bar for subsidiary standards.

Tonnellot and Boudin thermometers, standardized at the International Bureau in Paris, form the basis for temperatures. A 4-foot comparator is provided for the study of leveling rods. The 100-meter comparator for standardizing base line tapes is situated near the Observatory. Repsold cut-off tubes are used to transfer from the underground monuments to the tapes under field conditions. The standard is a 50-meter invar tape the length of which has been determined by the U. S. Bureau of Weights and Measures. The 100-foot chain tape comparator is located on the fourth floor of Lincoln Hall.

The laboratory also contains a Mendenhall half-second pendulum apparatus mounted upon a pier for the determination of the force of gravity. It is the standard type used by the Coast and Geodetic Survey.

6. **A Photographic Laboratory** for reproducing the appearance of tested specimens, for the purposes of the lecture room, as an aid in topographic surveys, and for the distribution of reprints of the collection of progress photographs of engineering structures owned by the College.

The equipment contains a revolving or panoramic transit camera constructed by the mechanician of the College from patterns generously supplied by the inventor, Mr. G. W. Parsons. This is especially valuable in topographic work since the entire sweep of  $360^{\circ}$  at a station can be included on a film 6-inches wide and about 70 inches long.

7. **The Fuertes Astronomical Laboratory and Observatory** is a substantial brick building 20 feet wide by 80 feet long, with a wing 14 by 24 feet. It contains a computing room, a transit room with four piers, a clock room, and three domes.

It is equipped with a Howard mean time astronomical clock, a Negus and a Nardin sidereal chronometer, four chromographs, a Troughton and Simms transit, a Fauth transit, 2 Fauth zenith telescopes, a Troughton and Simms 12-inch altazimuth, a Fauth 10-inch altazimuth, a  $4\frac{1}{2}$ -inch Clark equatorial, besides sextants, surveyor's transits, etc.

Students here become familiar with the observations, reductions and computations required for the determination of time, latitude, azimuth and longitude.

**Mechanician's Room.** This room is used in connection with the laboratories for the construction of special apparatus and instruments and for the maintenance of the equipment. It is well supplied with tools and special machines for the purpose, and is in charge of a mechanician.

**The Museums of the College of Civil Engineering** contain the following collections: 1. The Muret collection of models in descriptive geometry and stone cutting. 2. The DeLagrange general and special models in topography and geognosy. 3. The Schroeder models in descriptive geometry and stereotomy with over 50 brass and silk transformable models made in this College after the Oliver models. 4. The M. Grund collection of bridge and roof details, trusses and masonry structures, such as right, oblique and annular arches and domes, and several intricate models in stone cutting, supplemented by similar models by Schroeder and other makers. 5. A model railroad bridge of 100-foot span, one-fourth natural size, and a numerous collection of models of track details. 6. The Digeon collection of movable dams, artificial harbors and working models in hydraulic engineering. 7. Working models of water wheels, turbines and other water engines. 8. Several large collections of European and American progress photographs of engineering work showing the progress of construction, and many other photographs, blue-prints, models and diagrams. 9. An extensive collection of instruments of precision, such as a Troughton and Simms astronomical transit; a universal instrument by the same makers, reading to single seconds; sextants, astronomical clocks, chronographs, a Negus and a Nardin chronometer, an equatorial having an objective, by Alvan Clark, four and one-half inches in diameter, two large zenith telescopes of improved construction for latitude work, by the eye and photographic methods; spherometers and other instruments, like pier collimators, etc., necessary to complete a most efficient equipment of a training observatory. 10. A geodesic collection, consisting of a four-meter comparator, built at the College; a set of improved pendulums for gravimetric investigations; a secondary base line apparatus made under the direction of the Coast Survey; two new base line bars designed and con-



structed in the laboratories of this College, and all the portable astronomical and field instruments needed for extensive triangulations, including sounding machines, tachometers and heliotropes 11. Among the usual field instruments, there is nearly every variety of engineers' transits, theodolites, levels, solar and other compasses, omnimeters and tachometers, with a large number of special instruments, such as planimeters, pantographs, elliptographs, arithmometers, computing machines, altazimuths, sextants, telemeters, and altimeters, hypsometers and self-recording meteorological instruments of all descriptions.

### REQUIREMENTS FOR ADMISSION

(Candidates for admission should consult the General Circular of Information, which will be sent post-free on application to the Registrar of Cornell University, Ithaca, N. Y. All applications for admission to the freshman class should be addressed to the Registrar.)

The subjects that may be offered for admission are named in the following list and the figure in parenthesis following each subject indicates its value expressed in units and shows the maximum and minimum amount of credit allowed in the subject. A unit represents five recitations a week for one year in a study.

1a. English A . . . . .	(2)	8a. Ancient History . . . . .	( $\frac{1}{2}$ -1)
1b. English B . . . . .	(1)	8b. Modern History . . . . .	( $\frac{1}{2}$ -1)
2a. First Year Greek . . . . .	(1)	8c. Am. History, Civics . . . . .	( $\frac{1}{2}$ -1)
2b. Second Year Greek . . . . .	(1)	8d. English History . . . . .	( $\frac{1}{2}$ -1)
2c. Third Year Greek . . . . .	(1)	9a. Elementary Algebra . . . . .	(1)
3a. First Year Latin . . . . .	(1)	9b. Intermed. Algebra . . . . .	( $\frac{1}{2}$ )
3b. Second Year Latin . . . . .	(1)	9c. Advanced Algebra . . . . .	( $\frac{1}{2}$ )
3c. Third Year Latin . . . . .	(1)	9d. Plane Geometry . . . . .	(1)
3d. Fourth Year Latin . . . . .	(1)	9e. Solid Geometry . . . . .	( $\frac{1}{2}$ )
4a. First Year German . . . . .	(1)	9f. Plane Trigonometry . . . . .	( $\frac{1}{2}$ )
4b. Second Year German . . . . .	(1)	9g. Spher. Trigonometry . . . . .	( $\frac{1}{2}$ )
4c. Third Year German . . . . .	(1)	10. Physics . . . . .	(1)
5a. First Year French . . . . .	(1)	11. Chemistry . . . . .	(1)
5b. Second Year French . . . . .	(1)	12. Physical Geography . . . . .	(1)
5c. Third Year French . . . . .	(1)	13. Biology* . . . . .	(1)
6a. First Year Spanish . . . . .	(1)	14. Botany* . . . . .	( $\frac{1}{2}$ -1)
6b. Second Year Spanish . . . . .	(1)	15. Zoology* . . . . .	( $\frac{1}{2}$ -1)
6c. Third Year Spanish . . . . .	(1)	16. Agriculture† . . . . .	( $\frac{1}{2}$ -1)
7a. First Year Italian . . . . .	(1)	17. Drawing . . . . .	( $\frac{1}{2}$ -1)
7b. Second Year Italian . . . . .	(1)	18. Manual Training . . . . .	(1)
7c. Third Year Italian . . . . .	(1)		

### Four-Year Course

For admission under these requirements the applicant must offer: fifteen units from the list of entrance subjects arranged as follows: English (3),

\*If an applicant has counted Biology (1) he may not also offer Botany ( $\frac{1}{2}$ ) or Zoology ( $\frac{1}{2}$ ).

†Agriculture may not be counted for entrance to Arts and Sciences or Law.

history (1), elementary algebra (1), intermediate algebra ( $\frac{1}{2}$ ), plane geometry (1), solid geometry ( $\frac{1}{2}$ ), advanced algebra ( $\frac{1}{2}$ ), plane trigonometry ( $\frac{1}{2}$ ), french (3) or german (3), † elective (4).

### Five and Six-Year Courses

For admission to the College of Arts and Sciences under these requirements the applicant must offer: fifteen units from the list of entrance subjects arranged as follows: English (3), history (1), elementary algebra (1), plane geometry (1), foreign languages (5), elective (4).

For the six-year course the elective (4) must include the following: Intermediate algebra ( $\frac{1}{2}$ ), solid geometry ( $\frac{1}{2}$ ), advanced algebra ( $\frac{1}{2}$ ), plane trigonometry ( $\frac{1}{2}$ ).

### ADMISSION TO ADVANCED STANDING

A student who, having already attended some college or university, desires advanced standing in one of these courses should file with the Registrar of Cornell University, on an official blank to be obtained from him, a formal application for admission to advance standing, along with an official certificate from the college or university already attended, of his honorable dismissal; his entrance examinations in detail; his terms of attendance and the amount of work that he has completed; a detailed statement of the courses pursued for which he desires credit at Cornell. He should send also a catalogue of the institution, writing on it his name and marking the entrance requirements that he has satisfied and each subject that he has completed.

### ADMISSION AS SPECIAL STUDENTS

College graduates over twenty-one years of age, who wish to pursue advanced work without being candidates for a degree, may be admitted without entrance examinations. See General Circular of Information, page 22.

### First Degree

The degree of Civil Engineer (C. E.), is conferred upon such candidates as successfully complete one of the undergraduate courses.

### PRIZES

For scholarships and prizes, see the General Circular of Information, pp. 26-30 and the Pamphlet of Prizes.

**The Fuertes Medals**, founded by Professor E. A. Fuertes and consisting of two gold medals, each of the value of one-half the amount of the income provided by the endowment fund will be awarded under the following conditions.

One of these medals will be awarded annually by the University Faculty to that student of the College of Civil Engineering, who may be found, at the end of the first term of his senior year, to have maintained the highest degree of scholarship in the subjects of his course, provided he has been in attendance

†It is strongly recommended that at least three of these four elective units be offered in language and history. Agriculture may not be counted as an elective.



in the University for at least one and one-half years; and the other medal will be awarded annually by the Faculty to that graduate of the College of Civil Engineering who may write a meritorious paper upon some engineering subject tending to advance the scientific or practical interests of the profession of the civil engineer. It is desired that papers be presented on or before April 15th. If a paper is presented in a printed form, it will not be received if it has been printed earlier than the next preceding April 15th.

Neither medal shall be awarded unless it appears to the Faculty of the College of Civil Engineering that there is a candidate of sufficient merit to entitle him to such distinction. Candidates will be nominated to the University Faculty by the College of Civil Engineering annually.

When no medal is awarded, the money thus left unexpended shall be added to the principal of the Fuertes fund; or it may, at the discretion of the Board of Trustees, be given to aid needy and meritorious students of any college or department of the University.

**The William C. Seidell Book Fund** of \$1,000, founded by Gerrit S. Miller, the income of which is to be used for the purchase of books for poor young men who are working their way through the College of Civil Engineering, is available as follows: payments will be made by the Treasurer of the University upon the recommendation of the Director of the College, preference being given to members of the freshman class.

## COURSES OF INSTRUCTION

### 1911-12

The registration of new students will take place from 9 a. m. to 4 p. m., Monday and Tuesday, September 25 and 26, 1911. Seniors, juniors, and sophomores in good standing, may register in the College between 9 A. M. and 4 p. m. on Tuesday and Wednesday, September, 26 and 27, 1911.

A student must register for at least 12 hours each term.

The required courses in mathematics, physics, chemistry, geology and political economy are given in the College of Arts and Sciences; for a description of these courses see Courses of Instruction for that College for 1911-12. The required work in electrical engineering and steam machinery is given in Sibley College; for a description of these courses see Announcement of that College 1911-12.

### A FOUR-YEAR COURSE LEADING TO THE DEGREE OF CIVIL ENGINEER

Freshman year	No. course	First term	Second term
Analytics .....	5	4	—
Differential Calculus .....	5	1	2
Integral Calculus .....	5	—	4
Physics .....	1	4	—
Physics .....	6	—	4
Chemistry .....	1	—	6
Descriptive Geometry and Drawing .....	1	5	2
Elementary Surveying .....	10	3	—

In addition to the above the required Drill must be taken.

Sophomore year	No. course	First term	Second term
Geology .....	31	3	3
Mechanics of Engineering .....	20	5	5
Engineering Laboratory .....	22	1	3
Drawing .....	4 4 or 1 or 0 or 3		
Advanced Surveying .....	11	—	3
Materials of Construction .....	25	3 or 3	
Chemistry .....	6	5	—
Geodetic and topographical surveys .....	15	—	6

(Six weeks at close of year).

In addition to the above the required Physical Training must be taken.

The work of the junior and senior years consists of the studies of some one of the seven groups shown in the tabulation of the following page, viz.: (a) general; (b) geodetic; (c) hydraulic; (d) sanitary; (e) rail-road; (f) bridge. On registering at the opening of the junior year each student of that class shall elect a group which he is to take for the remaining two years of his course.

The general group is strongly recommended in the case of all students who have no urgent reasons for electing one of the other (special) groups.

### Junior Year

Course No.	Gen. (a) I-II	Geol. (b) I-II	Hyd. (c) I-II	San (d) I-II	R. R (e) I-II	Bridge. (f) I-II
— Political Economy .....	3 —	3 —			3 —	3 —
60 Railroads .....	4 4	4 4	4 2	4 2	4 4	4 4
71 Bridges .....	4 4	4 4	4 4	4 —	4 4	4 4
23 Hydraulics .....	5 —	5 —	5 —	5 —	5 —	5 —
40 Hydraulic Laboratory .....	1 —	1 —	1 —	1 —	1 —	1 —
52 Municipal Engineering .....	— 4	— 4	— 4	— 4	— 4	— 4
29 Engineering Problems .....	— 2	— 2	— 2	— 2	— 2	— 2
— Survey Computations and Mapping .....	— 4	— 4	— 4	— 4	— 4	— 4
50 Sanitary Biology .....	— —	— —	— —	3 2	— —	— —
76 Chemistry; Water Analysis .....				— 3		
E12 Electrical Engineering .....			3 —			
E23 Generation and Distribution of Electrical Energy .....				— 2		
	17 18	17 18	17 18	17 18	17 18	17 18

### Senior Year

17 Geodesy and Geodetic Laboratory .....		3 —	— —	— —	— —	— —
18 Geodetic Astronomy .....	— —	— 3				
19 Advanced Topographic Sur- veying .....		3 —				
26 Advanced Mechanics .....	3 —				3 —	3 —
31 Hydraulic Construction .....	3 —	3 —	3 —		— 3	
32 Water Power Engineering .....		— 3	— 3			
41 Hydraulic Measurements .....			— 3			
42 Experimental Hydraulic Motors and Pumps .....			3 —			
53a Sewage and Water Puri- fication .....	— 3					



51	Water Supply .....	3 -	3 -	3 -	3 -	3 -	3 -
53	Purification and Control of Water Supplies .....					- 3	
54	Sewerage Works .....					3 -	
55	Sanitary Laboratory .....					3 -	
61	Railroad Maintenance of Way						3 -
62	Railroad Operation and Management .....						- 3
71	Structural Design .....				- 4		
72	Reinforced Concrete Arch ..						2 -
73	Higher Structures .....						4 -
74	Masonry and Foundations ..	- 3		3 -			- 3
76	Steel Buildings .....						- 3
77	Concrete Construction .....	3 -	3 -	3 -	- 3	3 -	3 -
90	Specifications and Contracts	- 2	- 2	- 2	- 2	- 2	- 2
91	Engineering Design .....	- 3	- 3	- 3	3 -	- 3	- 3
92	Thesis .....	- 3	- 3	- 3	- 3	- 3	- 3
	Political Economy (Junior)			3 -	3 -		
	Political Economy (Special Senior) .....	3 -				3 -	
E12	Electrical Engineering .....	3 -	3 -		3 -	3 -	3 -
P11	Steam Machinery .....	- 3	- 3	- 3	- 3	- 3	- 3
		18 17	18 17	18 17	18 18	18 17	18 17

In the general group (a) a senior may with the approval of his class adviser substitute three hours in place of advanced mechanics, first term, or for masonry and foundations second term, or for both.

Engineering design in the general group and in the geodetic group may be taken in any one of the other groups by approval of the head of the department concerned.

For the thesis, work in engineering design or in investigation may be substituted; but this substitution must be approved by the professor in charge of the group which the student has elected. For the general group (a) the substitution must be approved by the class adviser and the department concerned.

## A FIVE-YEAR COURSE LEADING TO THE DEGREE OF CIVIL ENGINEER

For those students who wish to cover a somewhat broader field than that of the four year course in Civil Engineering, a five year course has been arranged as given below. The first two years of this course are given by the College of Arts and Sciences and the student registers in that college for this period. At the beginning of the third year, transfer is made to the College of Civil Engineering, and the student enters upon his regular engineering work.

The five-year course is of particular advantage to those students who have, in their home schools, found it impossible to secure adequate preparation in the advanced entrance requirements in Mathematics.

## FIRST YEAR—IN COLLEGE OF ARTS AND SCIENCES

	No. course	First term	Second term
Solid Geometry, Trigonometry .....	6a, 7a	6	—
Advanced Algebra .....	4b	—	5
Chemistry .....	1, 6	6	5
Other Art Subjects. (See lists, etc., below) .....		5	6

In addition to the above, the required Drill must be taken.

## SECOND YEAR—IN COLLEGE OF ARTS AND SCIENCES

	No. course	First term	Second term
Analytic Geometry .....	5	4	—
Calculus .....	5	1	6
Physics .....	1, 6	4	4
Other Art Subjects. (See lists, etc., below) .....		3	6
Descriptive Geometry and Drawing .....	1	5	2

In addition to the above, the required Physical Training must be taken.

## List of Courses open to Freshmen without Special Permission of the Administrative Board in Charge of Freshmen and Sophomores

Greek, 1, 3, 5, 6; Latin, 1, 3, 4; Germanic Languages, 1, 2, 3, 4, 5, 6, 7, 8; Romance Languages, 1, 2, 3, 12, 30, 32, 40, 42; English, 1; Music, 1; History 1, 21; Bibliography, 1, 1a; Mathematics, 1, 2a, 2b, 3, 4, 6, 7; Physics, 1, 5, 6, 10; Chemistry, 1, 6, 7; General Biology, 1; Botany, 1, 2; Entomology, etc., 2, 4, 5; Vertebrate Zoology and Neurology, 2, 5; Geology, 1, 2a, 2b, 2c.

This list is subject to the following restriction:

"He may not register or receive credit, during those years for any courses in mathematics, physics, or chemistry, or for any courses outside the College of Arts and Sciences, other than those there specified; nor may he register during his freshman or sophomore year, for any course in the College of Arts and Sciences, which is specified for a later year of the outline which he is following."

## Third Year—In the College of Civil Engineering

	No. course.	First term	Sec term.
Geology .....	31	3	3
Physical Experiments .....	14	2	—
Mechanics of Engineering .....	20	5	5
Engineering Laboratory .....	22	1	3
Surveying .....	10, 11	3	4
Materials of Construction .....	25	3	or 3
Drawing .....	4 4 or 1 or 0 or 3		

Fourth Year—In College of Civil Engineering  
(General Course)

Political Economy .....		3	—
Railroad Engineering .....	60	4	4
Bridges .....	71	4	4
Hydraulics .....	23	5	—
Hydraulic Laboratory .....	40	1	—



Municipal Engineering .....	52	—	4
Engineering Problems .....	29	—	2
Survey Computations and Mapping .....		—	4
Geodetic and Topographic Surveys .....	15	—	6
(Six weeks at close of year.)			

**Fifth Year—In College of Civil Engineering**  
(General Course)

Advanced Mechanics .....	26	3	—
Hydraulic Construction .....	31	3	—
Sewage and Water Purification .....	53a	—	3
Water Supply .....	51	3	—
Masonry and Foundations .....	74	—	3
Concrete Construction .....	77	3	—
Specifications and Contracts .....	90	—	2
Engineering Design .....	91	—	3
Thesis .....	92	—	3
Political Economy (Special) Senior .....		3	—
Electrical Engineering (E) .....	12	3	—
Steam Machinery (P) .....	11	—	3

**A Six-Year Course Leading to the Degree of Bachelor of Arts at the End of  
Four Years and of Civil Engineering at the End of Six Years**

Seniors in good standing in the College of Arts and Sciences, who have been in actual residence at least six terms, exclusive of summer sessions, and have a credit of at least 90 hours, may be registered both in the College of Arts and Sciences and in the College of Civil Engineering.

In accordance with this provision the following suggestion is given for a six-year course leading to the degrees of A.B. and C.E.

The following subjects are to be included in the course of study of at least 90 hours in the College of Arts and Sciences during the first three years of residence.

	No. course	First term	Second term
Analytic Geometry .....	5	4	—
Calculus .....	5	1	6
Physics .....	1, 6	4	4
Physics .....	10	1	1
Chemistry .....	1	6 (or 6)	
Chemistry .....	6	5 (or 5)	
Geology .....	31	3	3
Descriptive Geometry and Drawing .....	1	5	2

The following subjects in Civil Engineering are to be taken during the fourth year, when registered in both colleges.

	No. course	First term	Second term
History and Political Science .....		3	
Drawing .....	4	4 or 1	0 or 3
Elementary Surveying .....	10	3	—

Advanced Surveying .....	11	—	4
Mechanics of Engineering .....	20	5	5
Engineering Laboratory .....	22	1	3
Materials of Construction .....	25	3	or 3

The satisfactory completion of the above courses will lead to the degree of A.B. The work for the fifth and sixth years is to include the subjects of the junior and senior years of the General Group of the four-year course leading to the degree of C. E., except that course 51 in Political Economy is replaced by an elective.

Students desiring to take this course are recommended to confer with the Deans of the Faculties concerned.

### Graduate Study and Advanced Degrees

The facilities for study and research offered by the various laboratories of this College are available for graduate students; they will find also among both the regular and the elective courses given in the College, many that are suitable for graduate study.

The degrees of Master of Civil Engineering (M.C.E.) and of Doctor of Philosophy (Ph.D.) are granted upon fulfilment of the conditions prescribed by the Faculty of the Graduate School. See Announcement of the Graduate School.

### COURSES OF INSTRUCTION

1. **Drawing and Descriptive Geometry.** Freshmen. Credit, five hours first term, and two hours second term.

**Drawing and Lettering.** Six hours a week during first term. The work is sub-divided and is taken up in the following order. Geometrical Problems, which includes the drawing of the problem in pencil and ink; also a study of simple forms of projection in plan, elevation and section; thirty actual hours. Cross Sections, which includes practice in using drawing instruments in making the conventional signs of sections through different materials; nine actual hours. Tracing Details, which includes the use of tracing cloth in making tracings from blue prints of standard drawings, and from pencil drawings; also making blue prints from tracings; twenty-one actual hours. Freehand Lettering, which includes instruction and practice in a one-stroke freehand letter for working drawings. It is intended that the student shall acquire proficiency in the use of a letter applicable for shop and other drawings where a finished letter is not required but where rapidity and clearness are essential; thirty hours' actual time.

**Descriptive Geometry.** A study of the representation of lines, planes, surfaces, and solids, and their inter-relations. Warped Surfaces. Tangencies. A text-book is used and recitations are held upon the problems there stated or explained. A drawing period serves to allow the student to make drawings of original problems which are illustrations and applications of the problems in the book. Recitations, two hours a week. Original problems, two and one-half actual hours a week. Two hours' credit in second term. Intersections, shades and shadows, perspective. The inter-



sections include various forms of the intersections of planes with surfaces and solids, of surfaces with solids and of solids with solids. The work in shades and shadows includes shade lines on solids and the shadows of solids on planes and other solids. Original problems are assigned for work in the drawing room. Recitations, one hour a week. Original problems, two and one-half actual hours a week. Assistant Professor POND and Instructors TAYLOR and MORRIS. First term. Six sections in drawing, four sections in recitations, and eight sections in problems. Second term. Six sections in recitations, and six sections in problems.

4. **Drawing and Lettering.** Sophomores. Credit, four hours first term, for one-half of the class; and for the other half a credit of one hour first term and three hours second term. Preparation required: course 1. The work is sub-divided and is taken up in the following order: Lettering, which includes a study of and practice in different styles of letters, as Roman, Gothic, and Stump, together with their combination into appropriate titles; seventy-five actual hours. Isometric Drawing, which includes the principles involved in isometric projection, with practice in drawing from models and from dimension drawings; twelve actual hours. Line Shading, which includes the shading of flat and curved surfaces by lines variously spaced and by lines of different thickness; eighteen actual hours. Detail and Dimension Drawing, which includes the tracing of typical dimension drawings and in making detail drawings from sketches, models, and from other drawings on different scales; forty-eight actual hours. Topographic Signs, which includes practice in the different kinds of standard topographic signs for mapping; twelve actual hours. Tinting and Shading, which includes instruction in and practice with water colors, in the rendering of flat and curved surfaces, together with the use of crayon. Each student is required to make a number of plates and to become reasonably proficient with handling the brush and with the use of crayon; fifteen actual hours. Assistant Professor PARSON and ————. Three sections for each half of the class.

### Topographic and Geodetic Engineering

10. **Elementary Surveying.** Freshmen. First term, credit three hours. Use of steel tape, level, and transit. Fundamental surveying methods. Measurement of lines, angles, and differences of elevation. Land surveying; areas and plotting. U. S. Public Lands. Recitations, field work, computations, and mapping. Text-book: Johnson's Surveying. Three periods per week. Assistant Professors LELAND and BOOTHROYD and Instructors LAWRENCE and McCURDY. Eight sections.

11. **Advanced Surveying.** Sophomores. Second term, credit four hours. Preparation: Course 10. City, topographic, hydrographic, mine, and geodetic surveying and field astronomy. Precise measurements. Streets, lots, and grades. Transit and stadia; planetable; sextant. Soundings; stream measurement. Subterranean surveys. Earth volumes. Triangulation; base lines; precise leveling. Field determinations of azimuth, time, and latitude. Recitations, field work, and computations. Text-book: Johnson's Surveying. Four periods per week. Assistant Professors LELAND and

BOOTHROYD and Instructors LAWRENCE, McCURDY, and ———. Eight sections.

12. **Surveying** for students in Sibley College. Second term, credit two hours. Use of surveying instruments. Tape measurements. Leveling. Problems with transit and tape. Recitations, field work, computations, and plotting. Text-book: Breed and Hosmer's *Elementary Surveying*. Two periods per week. Instructors LAWRENCE and McCURDY. Five sections.

13. **Geodetic Surveying**. Seniors. Credit, five hours. Preparation required: course 15 or its equivalent. The course is divided into three parts, namely, astronomy, geodetic surveying, and the adjustment of observations by the method of least squares. The work in astronomy is devoted to the elements of practical astronomy with reference to the needs of engineers in the determination of azimuth and the auxiliary determinations of time and latitude. One afternoon a week is given to practice in computation including the reduction of the astronomic observations made at the junior camp of the preceding summer. In geodetic surveying, the methods of triangulation, base measurement, and precise leveling are studied, especially from the standpoint of economics. Methods of computation and reduction are considered. The application of the method of least squares to engineering problems is studied with special reference to the adjustment of triangulation and leveling. Campbell's *Practical Astronomy* and Crandall's *Least Squares and Geodesy* are used as text-books. Four recitations and one three-hour computing period a week. Assistant Professors LELAND and BOOTHROYD and Instructor UNDERWOOD. Recitations and computations, six sections.

14. **Least Squares; Adjustment of Observations**. Elective. Preparation required: calculus and physics. First term, credit two hours. Lectures and recitations. The course is designed for students who have experimental investigations in view. Applications are made to problems in physics, astronomy, mechanics, hydraulics, surveying, etc., with some attention given to the derivation of empirical formulae. Two hours a week, as may be arranged. Assistant Professor LELAND.

15. **Topographic and Geodetic Survey; Camp**. Juniors (for 1912 only). One month, beginning June 7; credit four hours. Preparation: course 11. Practical experience in surveying under field conditions. An extensive topographic survey is executed with the transit and stadia and the planetable, and field maps are made. Triangulation and precise leveling control the topographic work. A base line is measured with invar tapes. Astronomic observations for azimuth, latitude, and time are made. Each student takes part in all branches of the work. Field and office work six days and evenings per week. Assistant Professors LELAND and BOOTHROYD, Instructors UNDERWOOD, LAWRENCE, McCURDY, and AUSTIN, and five assistants.

(15). **Topographic, Hydrographic, and Geodetic Survey; Camp**. (Beginning with the class of 1914, course 15 will be given in the summer following the sophomore year, and after 1912 it will begin in June and continue for six weeks, with six hours credit.) Sophomores. Six weeks, beginning (for 1912 only) Wednesday, August 14, and closing the day before registration,



September 24; credit six hours. Preparation: course 11. In addition to the work outlined above for Course 15, there will be included a hydrographic survey and a number of problems pertaining to city surveying. The computations of the astronomic observations will also be made. Field and office work six days and evenings per week. Assistant Professors LELAND and BOOTHROYD, Instructors UNDERWOOD, LAWRENCE, McCURDY, and ———, and five assistants.

**16. Cartography.** Seniors. Second term, credit three hours. Preparation required: courses 13 and 15. One-third of the time is devoted to the computations resulting from the field work of the previous summer surveys, course 15, embracing base-line measurement, triangulation, and trigonometric and precise leveling. The work results in a set of permanent records, with the geographic positions, azimuths, distances and elevations of the various triangulation stations. The remainder of the course consists of the construction of a final topographic map of a portion of the area covered in the preceding summer survey. Several of the field sheets are combined for this purpose, and reduced in scale from 1:4800 to 1:12000, using the triangulation system as a basis for the work. Computing, three hours, and drawing, six hours per week. Assistant Professor LELAND and Instructor UNDERWOOD. Eight sections.

**17. Geodesy and Geodetic Laboratory.** Elective. Seniors and graduates. Preparation: course 13. Second term, credit three hours. A course for the consideration of special problems in geodetic work. Precise leveling. Deflection of the plumb-line. Figure of the earth. Use and investigation of geodetic instruments and apparatus; circles, levels, micrometer microscopes, standards of length, thermometers, pendulums, magnetic apparatus, etc. Subject to arrangement to meet the special needs of students. Lectures, reading, discussions, and laboratory work. Three periods per week. Assistant Professor LELAND.

**18. Geodetic Astronomy.** Elective. Seniors and graduates. Preparation: course 13. Second term, credit three hours. A study of the more precise methods of determining time, latitude, longitude, and azimuth, together with practise at the observatory in making and reducing the observations, including the determination of instrumental constants. Lectures, recitations, and observations. Three periods per week as may be arranged. Assistant Professor LELAND.

**19. Advanced Topographic Surveying.** Elective. Seniors and graduates. Preparation: course 13. Second term, credit three hours. Economics of surveying methods. Surveys for special purposes, such as: extensive construction work; storage and distribution of water for irrigation; earthwork on a large scale; lines of communication; topographic reconnaissance, etc. Photo-topographic surveying. Lectures and reading. Three hours per week. Assistant Professor LELAND.

#### Applied Mechanics and Hydraulics

**20. Mechanics of Engineering.** For sophomores in civil engineering and students specializing in chemistry. Throughout the year, credit five

hours for each term. Preparation required: Mathematics, course 5. A study of the principles, and applications to engineering, of the mechanics of solids; as relating to the mutual actions, motions, pressures, strength, stiffness, and resilience of the members of structures and machines. Original problems form a prominent feature. Statics of a material point and of rigid bodies. Centers of gravity. Chains and cords. Dynamics, (kinetics) of a material point. Impact. Virtual velocities. Centrifugal and centripetal forces. Pendulums. Moments of inertia of plane figures and of rigid bodies. Dynamics (kinetics) of rigid bodies. Work. Power. Energy. Fly-wheels. Friction. Graphical statics of mechanism. Dynamometers. General theorem of work and energy applied to machines. Stresses and strains. Tension. Shearing. Compression. Torsion. Flexure. Elastic curves. Safe loads. Columns. Text-books: Church's *Mechanics of Engineering*, and *Notes and Examples in Mechanics*, supplemented by other printed notes and problems. Lectures and recitations, daily except S, throughout the year. Professor CHURCH, Assistant Professors GEORGE, and RETTGER, and Instructors BARON and BRAUNER. Eight sections.

22. **Engineering Laboratory.** Sophomores. First term, credit one hour and second term, credit three hours. Must be preceded by, or taken with, course 20. Use of engineers' computing devices, viz: The common slide rule, the Fuller spiral slide rule, Thacher calculating instrument, and Goodchild chart. Use of the planimeter, adjustments and use of the cathetometer. Experiments involving the parallelogram of forces (funicular polygons). Determination of specific gravity with the Jolly balance. Centers of gravity of plates and prismoids (models). Efficiency of the inclined plane and of the compound crane. Systems of levers. Harmonic motion of masses, etc. Experiments in testing materials. Use of the 50,000 lb. and the 100,000 lb. Olsen machines, in tensile tests of bars of iron and steel. The Thurston and Riehlé torsion machines; determination of their constants; and tests of specimens for the determination of shearing stresses and of the modulus of elasticity for shearing. Flexure of wooden and steel bars; deflections and modulus of elasticity. Elongation of steel wires with observations by cathetometer or dial extensometer. Breaking tests of wooden columns. Moments of inertia of beam sections by graphic and analytical methods; and also by the use of the mechanical integrator. Use of the Kew magnetometer. Determination of specific gravity, fineness, normal consistency, soundness (normal and accelerated tests), time of set, and strength (both in tension and compression), of cements, neat and with sand. Determinations of voids in sands and broken stone. Laboratory work, two and a half hours a week in the first term and five hours in the second. Home work, three hours in the second term. Professor CHURCH, Assistant Professor MILLS, and Instructors TAYLOR, MORRIS, and ———. Six sections.

23. **Hydraulics.** Juniors. First term, credit five hours. (With topics in hydrostatics and pneumatics.) Preparation required: course 20. Fluids at rest. Hydrostatic pressure. Manometers. Strength of pipes. Pressure of water against walls and dams. Earth pressure. Immersion and flotation. Compressed air motors. Air compressors. Gas engines. Barometric leveling. Steady flow of liquids through pipes and orifices, and



over weirs. Fluid friction. Losses of head. Time of emptying vessels. Steady flow of water in open channels. Kutter's formula and diagrams based thereon. Steady flow of gases through pipes and orifices. Over-shot, breast, and undershot water wheels. Theorems for flow in a revolving pipe. Impulse wheels (Pelton, Girard, etc.). Turbines and reaction wheels. Backwater. Theory of turbine testing. Other hydraulic motors and machinery. As part of the work of instruction, experimental demonstrations are given in the Hydraulic Laboratory, at intervals of two or three weeks, to illustrate the principal phenomena of hydrostatics and hydraulics. Text-books: Church's *Mechanics of Engineering*, and *Hydraulic Motors*. Lectures and recitations, daily except S. Professors CHURCH and OGDEN, Assistant Professors SCHODER and TURNER. Six sections.

**25. Materials of Construction.** Sophomores. Either term (one-half of the class each term), credit three hours. Must be preceded by, or taken with, course 20. Text-book, Johnson's *Materials of Construction*. The materials studied are: lime, cement, stone, brick, sand, timber, ores, cast iron, wrought iron, steel, and some of the minor metals and alloys. The chemical and physical properties, uses, methods of manufacture, methods of testing, and unit stresses of each material are considered, particular stress being laid on those points of importance to engineers. The work is planned to coordinate with the course in economic geology and supplements that work where necessary. One lecture and two recitations a week. Assistant Professors MILLS and GEORGE. Four sections each term.

**26. Advanced Mechanics.** Seniors and graduates. First term, credit three hours. Preparation required: course 20. Linear arches. Curved beams. Special cases of flexure. Problems in the mathematical theory of elasticity. Thick hollow cylinders and spheres. Plates. Castigliano's Theorem of Least Work. Internal Work and its derivatives. Applications. Recitations. Three hours a week. Professor CHURCH. T Th S, 10.

**29. Engineering Problems.** Juniors. Second term, credit two hours. Preparation required: courses 20 and 23. The object of this course is to provide additional practice in using the principles and methods of Applied Mechanics, both of solids and fluids. A series of problems, such as occur in ordinary engineering practice, and covering a wide range of topics is given out for solution. Computations and reports; six hours a week. Professor CHURCH, Assistant Professors SEERY, GEORGE and TURNER. Four sections.

**30. Testing Materials.** Elective. Seniors and graduates. First term, credit three hours. Preparation required: courses 22 and 25 or their equivalents. Special investigations of an advanced nature of the properties of structural units and the materials of construction.

Tests may be made upon full-sized sections in iron and steel upon wooden columns, beams, and trusses; standard tests of paving brick and macadamizing materials; standard tests of cement and concrete aggregates; special investigations of the properties of concrete plain and reinforced upon full sized beams and columns; tests upon the bonding strength of steel and concrete; tests upon riveted steel joints; tests upon wire cables; etc.

Johnson's Materials of Construction and the publications of the American Society of Civil Engineers and of the American Society for Testing Materials are used as reference works. The aim of the course is not only to provide a knowledge of materials by observation of their behavior under stress, but also a knowledge of the technique of testing materials; a training in precise methods of observation and interpretation of results; and an appreciation of the relation of theoretical investigation to engineering practice. Advanced students are encouraged to make use of the laboratory facilities for special research work. Seven and one half hours a week as arranged. Professor CHURCH and Assistant Professor MILLS.

### Hydraulic Engineering

31. **Hydraulic Constructions.** Seniors and graduates. Either term, credit three hours. Lectures, recitations, and reports. Preparation required: courses 20 and 23; must also be preceded by or taken with course 51. Text-books: Wilson's Irrigation Engineering, with parts of Turneaure and Russell's Water Supplies and Thomas and Watt's River Improvement. Problems are assigned and must be completed before credit will be allowed. The work is divided into four parts, as follows:

Design and Construction of Dams, which includes the derivation of Wegman's formula for the profile of a high masonry dam and the working of a problem involving all the factors affecting the form of the cross section. The design and construction of earthen, timber, and metallic dams, are also considered. Water Storage, which includes the investigations of a reservoir site, surveys, borings, and cost of storage; the design of spillways and flood channels; and the effect on the stream discharge for various capacities of storage. Irrigation Engineering, which includes the problems peculiar to the irrigation of land with the necessary storage and distribution and with some attention to the agricultural problems involved. River Engineering, which includes a general study of river hydraulics with special reference to regulation, and bank protection. Assistant Professor SEERY. First term, T Th S, 11; second term, M W F, 11.

32. **Water Power Engineering.** Seniors and graduates. Either term, credit three hours. Preparation required: courses 23 and 40. Text-book: Mead's Water Power Engineering. The development of power on a stream, including the economic and commercial features affecting the value of a mill site; river hydraulics; the selection of turbines and a study of their characteristics; speed regulation; design of penstocks; the conveyance of water in canals, flumes, and pressure conduits; arrangement of machinery, etc., effect of pondage, storage and load factor, on capacity and equipment. The mechanical equipment is taken up and a problem illustrating the subject in a concrete example is worked by each student. Problems are assigned and must be completed before credit will be allowed. Assistant Professor SEERY. First term, M W F, 11; second term, T Th S, 11.

### Experimental Hydraulics

40. **Hydraulic Laboratory.** Juniors. First term, credit one hour. Must be preceded by, or taken with, course 23. The course is intended to



familiarize the student with the simpler hydraulic phenomena and with the observations and calculations involved. Written reports are required. The work includes: Logarithmic plotting and its applications; experiments on the flow of water over a weir, through several types of orifices, through a pipe, through a Venturi meter, and through a nozzle; and a test of a water motor. Text-book: Schoder and Turner's Hydraulic Laboratory Manual. One three-hour period a week. Assistant Professors SCHODER, TURNER, and WALKER. Six sections.

41. **Hydraulic Measurements.** Elective. Seniors and graduates. Second term, credit three hours. Preparation required: courses 23 and 40. The experimental portion of this course is intended to test the accuracy of measuring devices and methods as well as the exactness of hydraulic formulae. The work includes: Construction of pipe-flow diagrams; the Pitot tube; water-meters; nozzles; weirs; current-meters and floats in open channels; lectures on measurement of flowing water in large streams. Three afternoons a week. Professor HASKELL, Assistant Professors SCHODER and TURNER. M W F, 2-5.

42. **Experimental Hydraulic Motors and Pumps.** Elective. Seniors and graduates. Second term, credit three hours. The determination of efficiency, capacity, and characteristics of hydraulic machinery. Assistant Professor SCHODER.

43. **Experimental Hydraulic Investigation.** Elective. Seniors and graduates. Second term, credit three hours. This course is intended for those students who desire to carry on experimental investigations in hydraulics under more immediate direction and supervision than prevails in case of thesis work. Written reports are required, but need not be typewritten nor bound in thesis style. These reports are kept by the department. It is often possible and desirable for two students to work together on the same investigation. The field and scope of the investigation should be selected during the first two weeks of the term. For the experimental portion of the work the equivalent of three three-hour periods a week, is required. Assistant Professor SCHODER. T Th S, 8-11.

44. **Advanced Experimental Hydraulics.** The facilities of the hydraulic laboratory are available for thesis work and for experimental investigations by graduate students. Subject to special arrangements in each case. Professor HASKELL and Assistant Professor SCHODER.

### Municipal and Sanitary Engineering

50. **Sanitary Biology.** Juniors. Throughout the year. First term, credit three hours; second term, credit two hours. Preparation required: Chemistry, Course 6. Text-books: Ellis' Bacteriology, first term; notes on Algæ and Protozoa, second term. In the second term the work will begin at the conclusion of the recitations in Course 60 on earthwork and structures.

The course includes a study of the principles of microscopy, bacteriology and algology with especial reference to sanitary engineering. Bacteriological and biological examinations of water supplies are made and the identification and control of the various plant forms which render water supplies objectionable, or which indicate dangerous pollution, are taken up. Two

recitations and one laboratory period a week. Assistant Professor WALKER. Recitations, M W, 11. Three sections in laboratory, T W F, 2-4.30.

51. **Water Supply.** Seniors. First term, credit, three hours. Preparation required: course 23. Text-book, Turneure and Russell's Public Water Supplies, except Chaps. 8-10 and 19-23. Problems are assigned and must be completed before credit is allowed. These problems cover the various features of water works development as follows: Estimate of future population and consumption; hydrology of a drainage basin; rainfall and probable run-off; use of a mass diagram in determining necessary volume of storage; location of a conduit on a topographic map with calculation of size of conduit; determination of size of a distributing reservoir; design for adequate fire pressure in a distribution system; pumping and economic sizes for force mains for city supply with assumed topography; and computations for capacity of a ground water supply. One lecture and two recitations a week. Assistant Professor SEERY. Five sections in recitations.

52. **Municipal Engineering.** Juniors. Second term, credit four hours. Preparation required: course 23. Four hours per week, divided between lectures and recitations, as follows: Fifteen lectures and forty-five recitations. The lectures are divided as follows:

Specifications, earthwork, trenching, rockwork, illustrated description of sewer construction and sewage disposal plants, garbage collection and disposal.

The recitations are on the following books: Ogden's Sewer Design; Spalding's Roads and Pavements; Notes on Sewage Disposal.

There are also required from the students problems (one for each week) illustrating the matters taken up in the lectures as follows: specifications of tennis court; city sewage flow; city outfall sewer; pipe flow diagram; septic tank design; sedimentation tanks; disposal plant; culvert design; road location; pavement designs; estimates and specifications. Professor OGDEN and Assistant Professor WALKER. Four sections in recitations.

53. **Purification and Control of Water Supplies.** Seniors and graduates. Second term, credit three hours. Preparation required: course 23. Examination of water, physical, chemical and bacteriological; normal quality of surface and subterranean waters, with effects of storage; communicable diseases and water supplies; epidemics of typhoid fever and cholera with studies of etiology, etc.; purification of water, sedimentation and coagulation; slow sand filtration, theory, construction and operation, with examples; rapid sand filtration, theory, construction and operation, with examples; miscellaneous purification processes, aeration, softening, iron removal, sterilization, distillation, and purification by chemicals. Professor OGDEN. M W F, 11.

53a. **Sewage and Water Purification.** Seniors in the general group. Second term, credit three hours. Preparation required: course 52. A general course dealing with the principles and practices of filtration both of water and sewage. Lectures, recitations and problems. Professor OGDEN.

54. **Sewerage Works.** Seniors and graduates. First term, credit three hours. Preparation required: course 52. Three hours per week for 15 weeks, divided between lectures and recitations. Text-book is Ogden's Sewer Construction and Kinnicutt, Winslow and Pratt's Sewage Disposal.



The work is upon the construction and operation of Sewers and Sewage Disposal works, illustrated by lantern slides and by reference to recent descriptions of sewage disposal plants in the current literature. There are, generally speaking, three recitations or one week's work on each of the following topics: disposal by dilution (salt and fresh water); chemical precipitation; broad irrigation, with special reference to institutions; natural and artificial filtration beds; sedimentation and septic tanks; contact beds; and sprinkling filters. It is intended to differentiate this course from the junior work by making the latter chiefly a discussion of principles involved while the senior course is a detailed investigation of the methods of construction with the reasons involved. PROFESSOR OGDEN. M W F, 11.

**55. Sanitary Laboratory.** Elective. Seniors and graduates. Either term, credit three hours. Preparation required: course 52 and chemistry, course 6. This course offers a practical demonstration of some of the topics considered in courses 52, 53, and 54. Through the courtesy of the N. Y. State department of Health, students in Sanitary Engineering are permitted to work in the laboratory established by that department at Cornell University and may thereby become familiar with practical methods of water examination. Sand analyses are made, experiments in sedimentation carried on, and the operation of the city water filtration plant checked. Measurements of velocities and grades in the city sewers and a study of their inter-relation with sizes of pipes and depths of flow are made. Seven and one-half hours a week. Assistant Professor WALKER.

**56. Municipal Engineering.** Elective. Graduates. A discussion and study of questions other than water and sewerage dealing with the health of cities. Lectures, reports, and readings. Three hours. PROFESSOR OGDEN.

**57. Purification of Water.** Elective. Graduates. Specific problems in water purification; control of watersheds; effect of sedimentation on waters of different compositions; treatment of waters for particular requirements, such as removal of hardness, sediment, bacteria, etc. A report on some existing water system will be required from each student. Three hours. PROFESSOR OGDEN.

**58. Conference on present methods of sewage disposal.** Elective. Graduates. A critical study of the construction and operation of plants now in existence. Inspections and reports. Three hours. PROFESSOR OGDEN.

**59. A Laboratory Course for graduates,** devoted to some special problem of sewage or water, such as the operation of a water filtration plant, a sewage disposal plant, the purification of trade wastes, the value of disinfection, etc. PROFESSOR OGDEN and Assistant Professor WALKER.

### Railroad Engineering

**60. Railroad Surveying, Construction and Economics.** Juniors. Throughout the year, credit four hours a term. Preparation required: courses 10 and 11. The campus field work includes the laying out of circular and transition curves; the fixing of grade lines, cross sectioning and the staking out of masonry structures; the realigning of track and the location of turn-

outs. The Saturday field work consists in making the reconnoissance, preliminary, and location surveys for some ten miles of railroad. The topography is taken, the line is cross sectioned and data are obtained for estimates of cost, including the structures and rights of way. The drawing includes a map and a profile of the located line and a plan for one or more of the structures. The earthwork is computed from the cross sections, and complete estimates are made of quantities and costs, including structures. The recitations and lectures take up the field problems; the computation of earthwork; the cost of graduation, including tunnels, sub grade and track structures; track work; and the economics of railroad location and operation. Mimeograph notes on Railroad Surveying and on Railroad Construction, Crandall's Transition Curve and Earthwork Tables, Beahan's Railway Location, and Gotshall's Electric Railway Economics, form the bases of the work. Professor CRANDALL, Assistant Professor BARNES and Instructors EDWARDS, LAWRENCE, UNDERWOOD, and ——. First term, two three-hour periods of field work a week, and alternate Saturdays. Six sections. Second term, three recitations a week, six sections; and one period of two and one-half hours a week in mapping, five sections.

**61. Railroad Maintenance of Way.** Elective. Seniors and graduates. First term, credit three hours. Preparation required: course 60. The subjects treated are: track materials, with especial reference to the section, method of manufacture, and composition of steel rails; to the economics of tie preservation and the use of metal ties; and to the effect of quality of ballast upon maintenance. Machine and other methods of grading for second track; drainage; track laying both by machine and hand methods; ballasting and bringing new track to line and grade. Turnouts and switches; derailing switches; side tracks and yard tracks; sorting and terminal yards. Track maintenance; track tools; work trains. Action of car wheels on curves; widening of gage. Double tracking; separation of grades; and improvement in grades and alignment. Camp's Notes on Track is used as a text. Lectures and recitations three hours a week. Professor CRANDALL. M W F, 11.

**62. Railroad Operation and Management.** Elective. Seniors and graduates. Second term, credit three hours. Preparation required: course 60. The course is based on Byer's Economics of Railway Operation and Adam's The Block System, both of which are used as text-books. Under organization the following subjects are treated: The general principles underlying organization and the effect of each on efficiency; principal departments of railway service with a brief outline of the work of each; departmental and divisional systems of organization, with examples on various roads and discussion of adaptability of each. The duties of officers and the work of the different departments are taken up in considerable detail. The most important laws affecting railroads are given in discussing the work of the legal department. Freight traffic, freight houses, classification yards, car service rules, accounting, etc., are among the topics considered under operation. Signaling and interlocking and train rules are also considered. Lectures and recitations three hours a week. Assistant Professor BARNES. M W F, 11.



**63. Railroad Construction and Maintenance.** Special course for students in Sibley College. Second term, credit two hours. Preparation recommended: course 12. Second term. Webb's Railroad Construction is used as a text-book. Railroad surveying; reconnoissance, preliminary survey and location, simple curves with methods of laying out; purpose and nature of transition and vertical curves. Railroad construction; earthwork, surveys, methods and costs; rockwork; culverts and minor structures; trestles and bridges; and tunneling. Railroad maintenance; ballast, purposes, kinds and cross sections; ties, materials and treatment; rails and rail fastenings; joints; switches and crossings. Railroad economics; statistics; cost of distance, curvature, rise and fall and change in rate of ruling gradient and tonnage rating. Attention is given to comparing capitalized cost of structures, changes in weight of locomotives, etc. Two recitations a week. Assistant Professor BARNES. Hours to be arranged.

### Bridge Engineering

**71. Structural Design.** Juniors. Throughout the year, credit four hours a term. Preparation required: course 20.

**Structural Details.** The recitations cover the graphic analysis of simple beams and roof trusses in chapters I and II of Merriman and Jacoby's Roofs and Bridges, part II. The computations and drawing include complete detail designs and working drawings of wooden joints to resist large tensile stresses, and of a wooden roof truss for given specifications. The object of the course is to show how to apply the principles of mechanics to the design of every detail of the simple structures named, and to study the forms and strength of joints and fastenings used in heavy framing. The computations required are to be arranged in systematic order in the form of reports. Reference book: Jacoby's Structural Details. First term for 10 weeks. Computation and drawing, six hours a week.

**Bridge Stresses.** Stresses due to dead, live, and wind loads, initial tension, and impact. Panel loads and locomotive axle loads. Determination of the position of live loading for greatest stresses. Maximum and minimum stresses. Analytic and graphic methods are used. The principal types of simple trusses employed in modern construction are considered, in several cases both with and without counterbracing. Historical notes on truss bridges. The solution of many numerical examples taken from practice forms a prominent part of the class work. Each student is required to compute all the stresses in the main trusses and lateral bracing for a through Pratt truss railroad bridge which is to be designed subsequently. Text-books: Merriman and Jacoby's Roofs and Bridges, Parts I and II. First term. Recitations two hours a week for 10 weeks, thereafter four hours a week.

**Bridge Design.** Computations and drawing for the complete design of a steel railroad bridge of six or seven panels, the stresses for which were computed in connection with the previous study of bridge stresses. The computations to determine the sections of all members and of pins, pin plates, splices, and other details as well as of connecting rivets are to be

written up in the form of systematically arranged reports. The drawings consist of general detail plans showing the location of all rivets as well as the composition and relation of all members and connections. The final report is to give a full list of shapes and plates, and a classified analysis of weight for the span. Text-book: Merriman and Jacoby's *Roofs and Bridges*, Part III. Second term. Computation and drawing, 12 hours a week. Professor JACOBY, Assistant Professor DERICKSON, and Instructors DAVIS, BOWMAN, and BURROWS. First term, eight sections in recitations and six sections in computations. Second term, four sections.

**72. Reinforced Concrete Arch.** Elective. Throughout the year, credit two hours a term. Preparation required: course 20 and first part of course 71. The design of an arch of reinforced concrete including its abutments and centering. The general form and proportions are determined by two preliminary investigations. The final investigations of the arch ring under partial and full live loading are made in accordance with the elastic theory. The design is supplemented by several illustrated lectures on the different types of concrete arch bridges of recent construction, their principal details, methods of erection, and influence on design. Lectures, computation and drawing, six hours a week. Professor JACOBY, Assistant Professor DERICKSON and Instructor BOWMAN. Two sections in each term.

**73. Higher Structures.** Elective. Seniors and graduates. Either term, credit three hours. Preparation required: courses 20 and 71. Determination of the loading and stresses in continuous girders and trusses, swing bridges, and metallic arches. The arches include arch ribs and trussed arches with three and two hinges respectively. Both analytic and graphic methods are used. The latter include displacement diagrams to find the deflections of trusses and the reactions of statically indeterminate structures, and the use of influence lines to find their loading and stresses. These studies are accompanied by historical notes on arches, drawbridges and cantilever bridges. Text-book: Merriman and Jacoby's *Roofs and Bridges*, Part IV. Recitations, three hours a week. Professor JACOBY and Instructor DAVIS. First term, T Th S, 11. Second term, M W F, 11.

**74. Masonry and Foundations.** Seniors and graduates. Either term, credit three hours. Preparation required: course 20. Cofferdams, cribs, sheet piling, metal cylinder piers, pumping and dredging, the foundation, and the location and design of piers. Piles and pile driving. Pneumatic caissons. Open caissons. Caisson sinking. Deep and difficult foundations. Foundations of buildings: pile, caisson, steel, concrete. Underpinning. Examination of selected modern example described and illustrated in the engineering periodicals and transactions. Recitations, collateral reading and illustrated reports. Fowler's *Ordinary Foundations*. Three hours a week. Instructor DAVIS. First term, M W F, 11. Second term, T Th S, 11.

**76. Steel Buildings.** Elective. Seniors and graduates. Second term, credit three hours. Preparation required: courses 20 and 71. Mill buildings and tall steel buildings. Framing, trusses, beams and columns. Eccentric loading, wind bracing, connections and details. Roofs and floors. Weights and costs. Specifications. Design of a small mill building. In-



vestigation of the effect of wind on a knee-braced mill building bent. Recitations, lectures, and reports. Six hours a week for eleven weeks, after that three hours a week. Assistant Professor DERICKSON. T Th S, 11-1.

**77. Concrete Construction.** Seniors and graduates. Either term, credit three hours. The purpose of this course is to continue the study of reinforced construction and design begun in courses 20 and 25. While examples of actual construction are continually cited, special attention is paid to fundamental principles of design, to theoretical discussions, and to the interpretation of the results of experiments. It is the aim to give theory and practice equal weight, and to present the limitations as well as the advantages of this type of construction. The text used is Turneaure and Maurer's Principles of Reinforced Concrete-construction, of which all chapters excepting Chapter VIII (on the arch) are studied. The subject matter covered is as follows: Properties of the material; general theory; tests of beams and columns; working stresses and general constructive details; formulae; diagrams and tables, building construction; retaining walls and dams; miscellaneous structures. At each recitation a problem is assigned, requiring about an hour's time to solve. One recitation and two drawing periods a week. Assistant Professor DERICKSON and Instructors DAVIS and BOWMAN. Four sections in recitations and three in computations and drawing for each term.

#### Specifications, Designs, etc.

**89. Cost Keeping and Management.** Elective. Seniors and graduates only. First term, credit two hours. An elementary course on the principles which govern the organization and management of forces on construction, systems of payment, measurement of efficiency and cost keeping; with illustrative examples. Assistant Professor BARNES. T Th, 11.

**90. Specifications and Contracts.** Seniors. Second term, credit two hours. Synopsis of the law of contracts as applied to engineering work. Study of the general and of the special clauses in specifications; classification of specifications; typical contracts and specifications. Practice in writing specifications. Acquisition, ownership and conveyance of land; rights and liabilities in streams, surface and underground waters; property rights defined by boundaries; and determination of boundaries of land. Johnson's Contracts and Specifications is used as a text, and Wait's Law of Operations in Engineering Construction as a reference book. Lectures and recitations, two hours a week. Professor CRANDALL, Assistant Professor BARNES. Six sections.

**91. Engineering Design.** Seniors. Credit three hours. The student is required to make complete designs in one of the following sub-divisions, subject to approval; hours to be arranged.

Engineering Design in the General Group and in the Geodetic Group, may be taken in any one of the other groups by approval of the head of the department concerned.

(c) **Hydraulic Engineering.** Second term. Preparation required: courses 23 and 29. Design of hydraulic works, plants and appliances, such as

aqueducts, canals, irrigation works, locks, lift-locks, lock-gates, dams, reservoirs, stand-pipes, elevated tanks, systems of water works (gravity, pneumatic or pumping systems), drainage works, power plants, water turbines and other hydraulic motors and machinery, etc. Professor CHURCH and Assistant Professors SEERY and GEORGE.

(d) **Sanitary Engineering.** First term. This course must be preceded by or taken at the same time with course 54 and may not otherwise be elected. The following problems assigned in 1909-10 indicate the scope of the work:

1. Computations, design and detail drawings for the wooden forms needed for brick or concrete sewers of various diameters and forms of cross section.
  2. Computations, design and detail drawings for a pile foundation to support sewers from 3 to 10 feet diameter.
  3. Design and detail drawings for patterns of cast iron manhole covers.
  4. Computations, design and detail drawings for flap valve at outlet of settling tank; the design involving a lifting device.
  5. Design and detail drawings of a sewage screen, involving a device for raising screen for cleaning.
  6. Computations, designs and detail drawings for an inverted siphon for sewage flow. The problem involves a flushing gate and overflow as well as manholes.
  7. Design of disposal plant for a small community as an asylum or school.
- Professor OGDEN.

(e) **Railroad Engineering.** Second term. Must be preceded by, or taken with course 61. Individual problems are assigned in conference with the student. These include: designs for track layouts and details, small depot buildings and freight houses, culverts, bridge masonry, subway construction; grade separation structures; water tanks, track and elevated, of steel, timber or reinforced concrete; coaling plants, etc. Bills of material and estimates of cost are usually required. Professor CRANDALL.

(f) **Bridge Engineering.** Second term. Course 71 is required as general preparation for engineering design in bridges and buildings. Course 73 is required in preparation for designs relating to draw, cantilever, suspension and metallic arch bridges. Course 77 is similarly required for designs of bridges and buildings in reinforced concrete, course 72 being taken at the same time as engineering design, or previously. Professor JACOB, Assistant Professor DERICKSON.

92. **Thesis.** Seniors. Credit, three hours. The thesis is intended to demonstrate the ability of the student for independent investigation, or his capacity to apply the fundamental principles acquired in this course to the study of some special problem related to Civil Engineering. The latest date for filing the subject with the Dean of the College is October 15 for the first term, and January 15 for the second term. The plan of work is to be submitted to the professor having charge of the subject, to whom also regular reports are to be made, showing the progress of the investigation. The latest date for presenting the completed thesis is June 1. Regarding the



approval of the subject or substitution for thesis see notes under the requirements for the four-year course.

### **Special and Graduate Courses**

All of the elective courses are suitable for graduate and advanced students, and may be taken by them in the regular classes. Other special courses will be arranged to suit the requirements of graduate students. These courses are intended to be pursued under the immediate direction of the professor in charge, the student being usually free from the restrictions of the class room and working either independently or in conjunction with others taking the same course.









## OFFICIAL PUBLICATIONS OF CORNELL UNIVERSITY

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These publications include the Book of Views of the Campus, for which a charge of twenty-five cents a copy is made, and the following publications, any of which will be sent gratis and post-free on request:

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Courses of Instruction in the College of Arts and Sciences,

Announcement of Sibley College of Mechanical Engineering and the  
Mechanic Arts,

Announcement of the College of Civil Engineering,

Announcement of the College of Law,

Announcement of the College of Architecture,

Announcement of the Medical College,

Announcement of the New York State College of Agriculture

Announcement of the Winter Courses in the College of Agriculture,

Announcement of the New York State Veterinary College,

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